MEASUREMENT TECHNOLOGIES

MONITORING PLAN
TO PERFORM AMBIENT AIR AND METEOROLOGICAL MONITORING
FOR
TRUE GEOTHERMAL ENERGY COMPANY
KILAUEA MIDDLE EAST RIFT ZONE, ISLAND OF HAWAII

DECEMBER 1989

CN-137

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1.0 Introduction

This document presents the Air Quality Monitoring Plan of Operations for the True/Mid-Pacific Geothermal Development Project (True/Mid). The monitoring plan documents the air quality and meteorological monitoring program to support the incremental exploration and development of the Kilauea Middle East Rift Zone Geothermal Resources Subzone (GRS), Puna District, Island of Hawaii. The Air Quality and Monitoring Plan is submitted to the Director of the Hawaii Department of Health (DOH) who has the State's responsibility for implementing EPA and NIOSH air quality regulations in Hawaii.

The plan addresses primarily the monitoring to be accomplished during the exploration phases of the project. If significant resource is discovered, True/Mid may make a decision to proceed into the resource development once exploration is complete. This decision will be derived after the resource has been characterized, a feasibility study completed taking into account new and future development technology, economic feasibility and the environmental concerns of the public.

As the exploration of the resource proceeds, changes or/and additions to the monitoring plan and operations may be required to meet the environmental concerns of the public. These operational changes will be submitted to the Director (DOH) for approval and to the Director of the Department of Land & Natural Resources (DLNR) for review and approval. The major components of the monitoring program for the exploration phases are:

1. Design and implement a meteorological monitoring program to develop on-site data bases to characterize drainage winds and potential stagnation zones in the project area as a basis for determining maximum impact areas for potential project emissions.

2. Conduct air quality and meteorological monitoring in the nearest residential community that may be a maximum impact area for well drilling, venting and testing to capture the potential impact of these intermittent sources.

The monitoring plan is consistent with the guidelines and requirements of the U. S. Environmental Protection Agency and will provide the information necessary to determine compliance of all phases of the project with applicable ambient air quality standards.

2.0 Project Description and Organization

This section describes the monitoring program, how the program will be managed and introduces the Measurement program organization with the key program team members identified.

2.1 Project Description

Section 1 (Introduction) provided the objectives of the True/Mid-Pacific Geothermal Development Project (True/Mid). This section outlines the monitoring program to be implemented during the exploration and development of the Kilauea Middle East Rift Zone Geothermal Resource Subzone (GRS) by True/Mid. The monitoring program was previously submitted to the Director of the Hawaii Department Of Health (DOH) who has the State of Hawaii's responsibility for implementing EPA and NIOSH air quality regulations in Hawaii. The monitoring program outlined reflects final monitoring negotiations between True/Mid and DOH in October 1989. Measurement Technologies participated in the final monitoring negotiations.

True Geothermal Energy Company (True) funded Measurement to assemble and operate two ambient air/meteorological monitoring stations. The monitoring stations and site monitoring parameters are identified in Table 2-1. Each of the monitoring stations/sites will be equipped to meet the objectives of True/Mid and insure the public is protected from potential emission releases during drilling/development of the Kilauea geothermal resource.

Six types of monitoring will be performed during the drilling/development of the Kilauea geothermal resource. These types of monitoring are monitoring:

- Continuous meteorological monitoring in the Kaohe Homesteads, the nearest residential community adjacent to the development area and at drill site A1 to determine site specific meteorological data;

- Continuous hydrogen sulfide (H2S) and sulfur dioxide (SO2) monitoring to determine background and potential emission release concentration levels possibly impacting the Kaohe Homesteads;

- Determine concentration levels of airborne metals and particulates at the Kaohe Homesteads;

- Determine concentration levels of metals and anions in the rainwater used for potable water by the residents of the Kaohe Homestead residents;

- Determine if hydrogen sulfide background concentration levels are elevated in the drilling/development areas and to detect concentration levels in the event of a hydrogen sulfide release; and

- Determine Radon background level in the drilling/development areas.

Measurement will operate the monitoring stations as stated in the Introduction (Section 1) according to EPA PSD guidelines. Monitored parameters that are not addressed in the PSD guidelines will be monitored by the NIOSH methods or the latest state-of-the-art measurement/analytical methods accepted by and being performed by the environmental monitoring community. Monitoring operations are described in detail in Section 5.

Measurement will provide four quality assurance audits (one each monitoring quarter) for each monitoring station operational year. The quality assurance audits will consist of verifying the accuracy of each measured air quality/meteorological parameter collected by separate standards from operations standards or by side-by-side comparisons with

Table 2-1. Monitored Parameters

PARAMETER	SITE 1	SITE 2 (MET)
HYDROGEN SULFIDE (H2S)	X	8 PLS
SULFUR DIOXIDE (SO2)	X	
WIND DIRECTION	X	X
WIND SPEED	X	X
VERTICAL WINDS		X
SIGMA THETA	X	X
SIGMA W		X
TEMPERATURE	X	
PRECIPITATION	X	
RAIN WATER (ANIONS & DISSOLVED METALS)	3 PLS	
METALS (ATMOSPHERIC PARTICULATE)	X	
TOTAL SUSPENDED PARTICULATES (TSP)	X	
INHALEABLE PARTICULATES (PM-10)	X	
RADON		X

calibrated collocated sensors. The quality assurance and quality control program is described in detail in Section 5.

Measurement will provide monthly, quarterly, and annual data reporting of collected monitoring data. Reporting details are provided in Section 7. Data reports will be generated and submitted within approximately four weeks of completion of each monitoring period. Data reports will be made available for True/Mid and DOH after review by True/Mid.

2.2 Project Organization

The success of the air quality monitoring program with critical data analysis and interpretation, depends upon the expertise and close coordination of project personnel to insure that monitoring program objectives are fulfilled. Measurement has assembled a project team consisting of Dr. Chuck E. Schmidt, an air toxic consultant, to perform review of collected air quality and rainwater data; and Measurement Technologies to perform air quality monitoring, required quality assurance services, and provide data analysis.

The project team assembled by Measurement and their respective responsibilities are as follows:

Measurement Technologies - Overall project management, monitoring network design and execution, operations, and data reporting.

Dr. C. E Schmidt - Air toxic data analysis.

Measurement will utilize senior staff members as program organization task managers and program contacts. The program team management/organization chart is shown in Figure 2-1. Mr. Dwight Gordy of Measurement Technologies will act as overall Program Manager and Monitoring Program Manager. Mr.

Joseph Gordy and Dr. Chuck E. Schmidt will act as Co-Data Analysis Managers. As Co-Data Analysis Managers, they will oversee the data processing and reporting. Mr. Joseph Gordy will concentrate on the analysis of the meteorological and criteria pollutant data, while Dr. Schmidt will concentrate on review of the non-criteria data and analyses methods. The two will review each others analyses and make recommendations on operations as required to the Program Manager.

Mr. Dwight Gordy will be in charge of the field monitoring program which includes instrumentation, network design, monitoring/operations and quality assurance. Quality Assurance Management will be performed by Mr. Joel Cordes with input from the Data Analysis Managers.

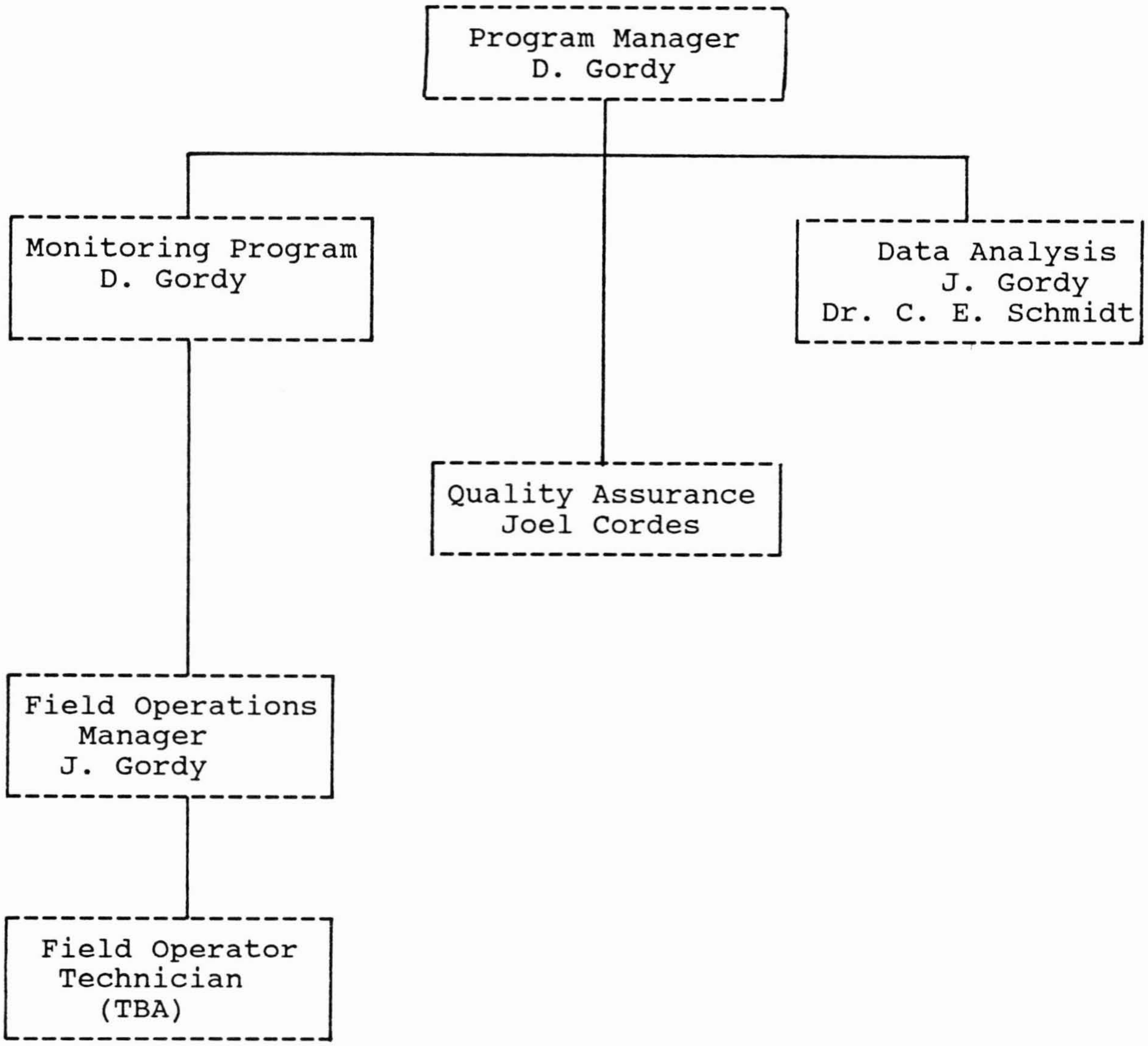

Figure 2-1. Project Organization

3.0 Source Environment Description

This section describes the land use, area meteorology, and the monitoring sites for the True/Mid development project.

3.1 Land Use and Description

The True/Mid-Pacific Geothermal Development area (KMERZ A1) is located on the Kiluea middle east rift zone approximately 7 miles west of Pahoa, Hawaii. The development area is located on 9000 acres of a larger 25,000 property tract owned by Campell Estates. The development wells are to be located on these 9000 acres zoned as conservation, protected subzone. This means the area is protected for its natural land value. Overriding this classification is the determination of a geothermal subzone. The only possible use of the land is for the collection of scientific data and the exploration of geothermal energy resources. Figure 3-1 provides a map of the development area.

The land is in general inaccessible, heavily forested and covered with lava from recent and past flows. The development area elevation is approximately 1,500 feet. The land in general slopes gently to the northeast at 70-100 feet of elevation for each mile of distance.

The Kaohe Homesteads are located approximately 2.5 miles to the northeast of the development area. The Kaohe Homesteads are 5-10 acre tracts zoned for agricultural use. Much of the area is abandoned sugar cane fields.

3.2 Climatological and Meteorological Description

The island of Hawaii is located within a belt predominated by northeasterly trade winds generated by a semipermanent Pacific high pressure cell to the north and east.

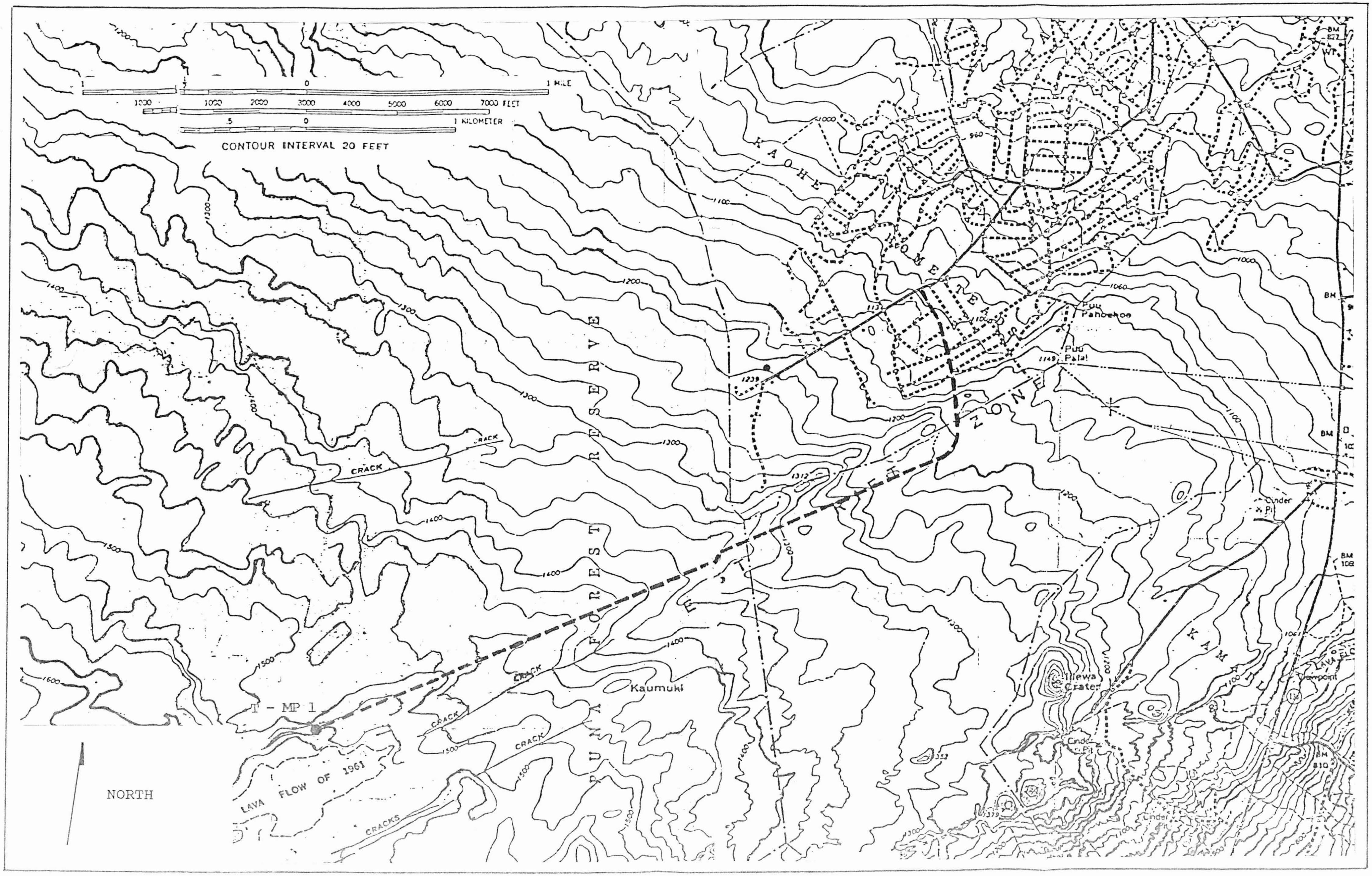

Figure 3-1. Development Area Map

The island terrain greatly influences the climate for most geographical areas of the island. Rainfall varies greatly with elevation and location and the effect of the persistent northeasterly trade winds. Temperatures are generally uniform from day to day and season to season at near sea level elevations.

Meteorological data for the eastern portion of the island has been collected at the City of Hilo, Hawaii for about fifty years. Hilo is about 20 miles northwest of the development area. The Hilo meteorological site is located on the coast.

The northeasterly trade winds are uplifted over the prevailing rising topography causing increased cloudiness and precipitation to occur with elevation. Precipitation occurs much of the year. Mean annual rainfall is about 100 inches on the coast to over 300 inches at elevations of 2,000 to 3,000 feet. Sea breezes created by daytime heating of the land move onshore and upslope, causing afternoon and evening cloudiness and showers.

Data collected near the HGF geothermal development site located near the development area, show winds to occur primarily from a northerly or westerly direction. Winds occur from the northeast about 40 percent of the time. The high occurrence of winds from the west are associated with the downslope winds which occur primarily during the night and early morning. Wind speeds average about 2.9 meters/second for all directions, with the strongest being about 3.7 meters/second. The higher winds generally occurring from the southwest. Winds are generally strongest mid-afternoon and lightest midmorning (8-11 AM).

Because the island of Hawaii is located near the equator, seasonal weather variations are minimal. About sixty percent (130 inches) of the precipitation falls between the months of November and April. Precipitation in Hilo varies from about 130 inches a year at coast and 200 inches a year at mountainous regions. The average temperature in Hilo is about 74 degrees F with about a 5 degree F variation from season to season. The average daily temperature range is about 16 degrees F. Relative humidity in the Hilo area is moderate to high without being oppressive because of the prevailing trade winds. Except for heavy rains, severe weather seldom occur.

3.3 Monitoring Site Descriptions

3.3.1 Site 1 Air Quality

The primary monitoring site is designated as "Site 1 Air Quality". This monitoring site is located in the Kaohe Homesteads near the end of Kaohe Homesteads Road in a large 5 acre residential home lot. This site was chosen because it represents the nearest residential impact area for potential emission releases from the geothermal development. The site is in general upwind of the development area. The site is excellent for determination of area background concentration levels of the compounds of interest and for determining the influence of the development on background concentration levels when winds are from the southwest. A map of the monitoring site is provided in Figure 3-2.

The monitoring station is located in a large open field approximately 400 feet by 600 feet located behind the residence. The open field gently slopes to the northeast. The open field is bordered by trees that are about 40 feet in height. The meteorological instrumentation (wind direction, wind speed, and temperature sensors) are mounted atop a 10 meter (about 33 feet) meteorological tower attached to the side of the monitoring station. The stainless steel intake manifold inlet extends out the roof 1 meter (about 3 feet).

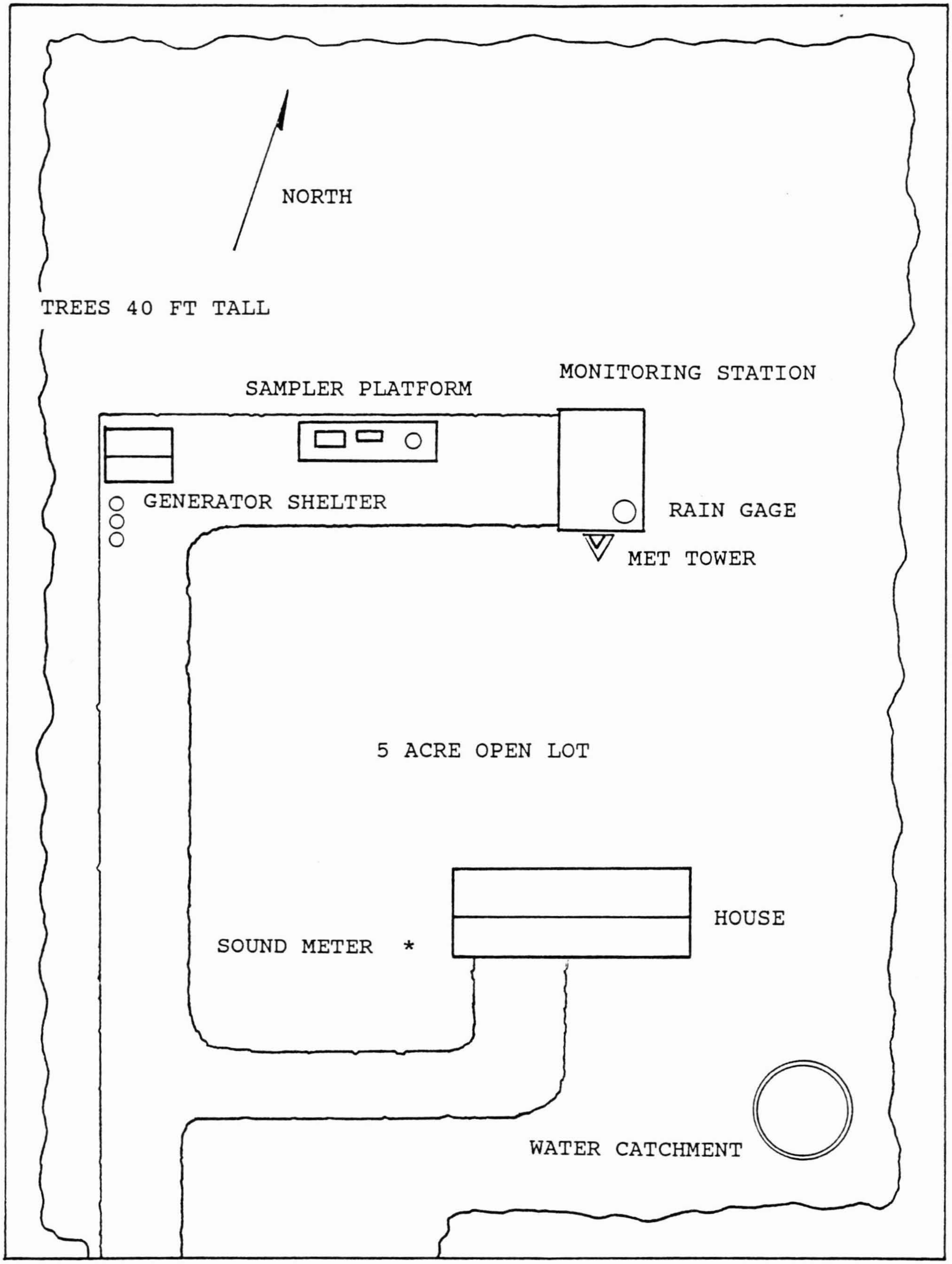

Figure 3-2. Site 1 Air Quality Monitoring Site Map

The integrated sampler and particulate samplers are placed on a wooden platform about 30 feet to the west of the monitoring shelter. The inlet to the particulate sampler is 1 meter in height. The inlet to the integrated sampler is 1.5 meters (about 5 feet) height.

The air quality station obtains electrical power from one of two propane generators housed in a small building about 200 feet to the west of the monitoring station. Propane is used as a fuel because the emissions from the combustion of propane will not interfere or show false readings to the sulfur dioxide or hydrogen sulfide analyzers.

The three plastic rain gages for collection of rainwater samples are located in the Kaohe Homestead area on residential properties along Kaohe Homesteads Road. The first rain gage is located next to the particulate platform at the monitoring station site. The second gage is located on a open residential lot about 1,200 feet northeast of the monitoring station site. The third rain gage is located on the property of a large commercial horticulture farm about 1,200 feet farther to the northeast of the second gage site. The tipping bucket rain gage for continuous collection of real time rain data is located atop the monitoring station roof.

3.3.2 Site 2 Met

The second monitoring site is designated as the meteorological site "Site 2 Met". This site is located at drill site 1 shown on the area map (Figure 3-1). The purpose of this monitoring site is to collect meteorological data in the development area for emissions modeling once the geothermal wells are completed and a commercial geothermal electrical generation facility is to be constructed. Meteorological sensors are located atop a 10 meter (about 33 feet) meteorological tower located at the edge of the large water storage pond. A map of drill site 1 with the location of the meteorological tower is shown as Figure 3-3.

Real time wind direction, vertical wind speed and horizontal wind speed data is collected on the meteorological tower. Eight passive hydrogen sulfide dosimeter badges are placed on fence posts located along the perimeter of the drill site. A Radon detector is located to the south of the drilling platform.

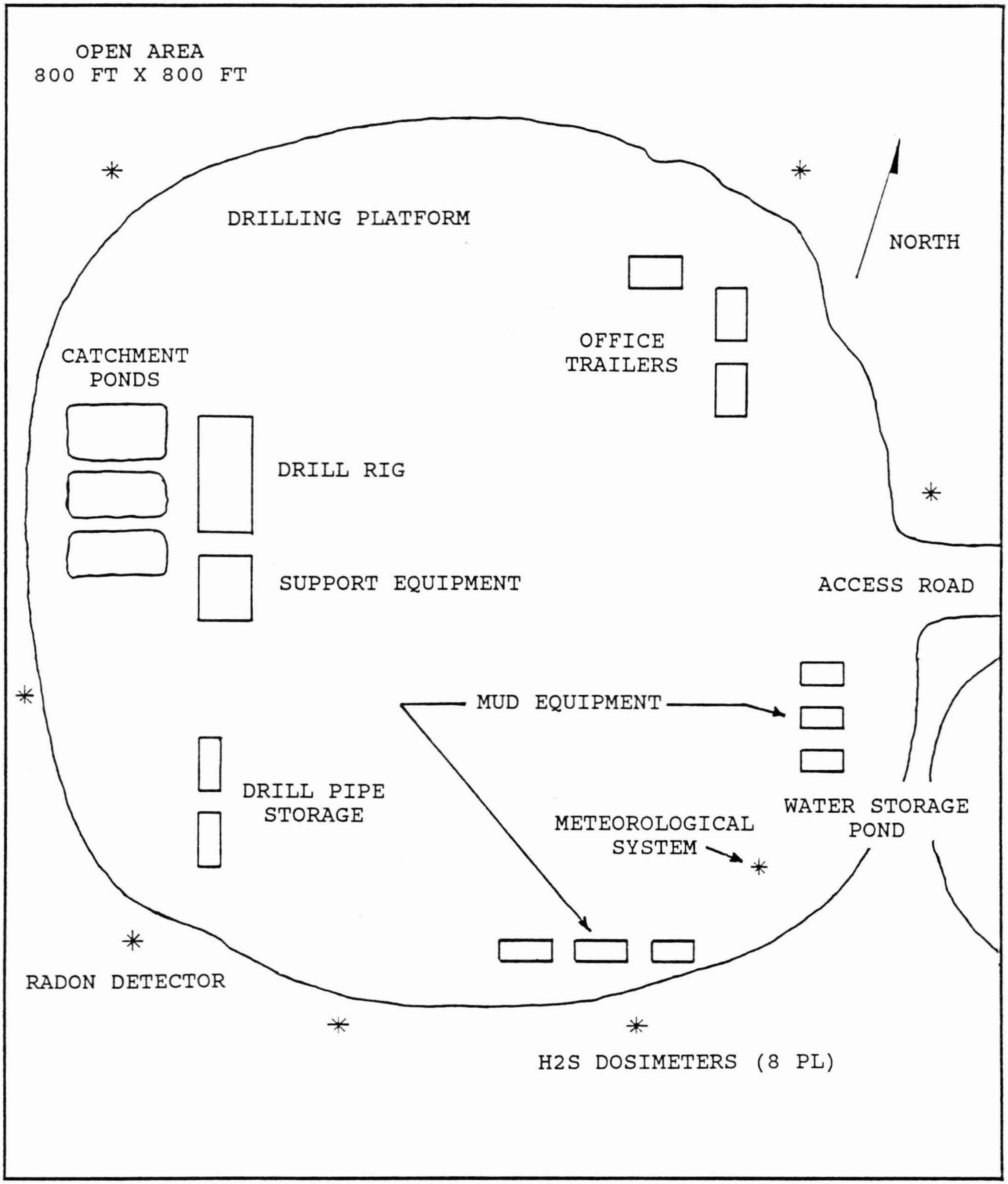

Figure 3-2. Site 2 Meteorological Monitoring Site Map

4.0 Monitoring Operations

Measurement recognizes the important role monitoring operations plays in the success of a monitoring program. The operating procedures that will be used in this monitoring program have been proven to be successful in numerous air quality studies. The monitoring program will be operated in accordance with the guidelines provided in the EPA's "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)", EPA-450/4-007, May 1987.

The day-to-day field operations will be conducted by an on-site operator which will be supported from Measurement's home office in San Luis Obispo, California (SLO). The Measurement Program Manager will be responsible for the supervision of on-site personnel and daily review of the monitoring program data and operations status. Responsibilities will include:

- Supervision of the deployment of the monitoring stations;
- Supervision of the field operator/instrument technician (operator);
- Coordination of logistical support activities between Hilo, Hawaii and SLO;
- Monitoring of operational schedules, timeliness and milestones;
- Review and implementation of operational procedures and upgrades as necessary to ensure that data capture and data quality requirements are met;
- Remote inquiry of the air monitoring data from the monitoring stations via telecommunications once available; and
- Investigation of problems identified through quality assurance activities.

The operator will be supplied with an "Operator Checklist" to aid the operator in the inspection of the monitoring stations. It will contain a sufficient number of key items with interactive "prompts" to alert the operator of existing or potential problems. During the station visit, the operator will be required to document the previous zero/span calibration data at each station location. This data will be used to compile drift control information.

Remote inquiry of each monitoring station will be made three times a week (if telecomunications available) to allow the SLO office to assess the operational status of each monitoring station by checking the 24-hour data summary from the station data acquisition system. In the event phone lines cannot be installed at the monitoring station locations, the data acquisition system data cartridges will be changed bi-weekly and sent to SLO for reading and analyses.

If problems are detected in the review process, the Program Manager will consult with the operator to plan an appropriate course of corrective action. Due to the complexity and importance of a program of this type, the stations will be visited a minimum of once every twenty-four hours, and under normal conditions, once early in the morning and late afternoon. The purpose of the station visits is to determine if malfunctions have occurred, determine the severity of the malfunction, and initiate immediate repairs if required.

If there is a hydrogen sulfide or sulfur dioxide episode, the operator will immediately notify the True Operations Manager and attempt to determine the source. During the inspection of each station, the operator will be responsible for the following routine duties:

- Visually scan the hard copy printout at each monitoring station for obvious anomalies, e.g., high SO2 levels with no H2S level, constant wind direction values, etc.;

- Perform routine visual checks of all meteorological parameters to determine if data are reasonable;

- Check the previous zero/span calibration data for each air quality analyzer to insure that the analyzer is operating within specified tolerances;

- Review the quality control documentation to verify that all equipment and analytical instrumentation are operating within prescribed limits; and

- Report the operational status of the program to Measurement personnel in SLO.

The operator will also be responsible for:

- All routine operations of the monitoring stations, e.g., changing sample line filters, scrubbers, data cartridges, bottled gasses, etc.;

- Operation/maintenance of the two propane generators;

- Corrective maintenance on the air quality analyzers, data acquisition system, and meteorological instrumentation;

- Maintenance of monitoring station log books;

- Calibration of the air quality analyzers;

- Cleaning of sample hardware to prevent contamination of collected samples;

- Shipping the collected samples to the analytical laboratories and filing out sample custody forms;

- Collect rainwater samples and change sample filters;

- Completion of "Operator Checklists," calibration forms, malfunction reports, etc.;

- Telephone contact reporting to the Program Manager;

- Checking error messages such as power failures on the data acquisition systems;

- Checking data storage space left on data cartridges;

- Noting in the station log book any activities around the monitoring stations that may affect data quality (activities may be fires, maintenance activities, low level inversions, etc.);

- Noting equipment/analyzer downtime other than for routine calibrations;

- Performing scheduled and unscheduled maintenance and calibration of air quality analyzers and meteorological sensors; and

- Performing routine housekeeping which includes cleaning intake manifolds, vacuuming floors, filing data, trash disposal, etc.

5.0 Quality Control/Quality Assurance Program

The quality control/quality assurance program consists of two distinct and equally important functions. One function is the control, and improvement, of the quality of the collected monitoring data by implementation of a effective quality control program. The other function is the implementation of a program to assess the quality of the collected monitoring data by determining the accuracy and precision. The two functions complete a closed loop; that is, when the data quality is inadequate, the control efforts must be increased until the collected data quality is acceptable.

Measurement's approach to monitoring programs/studies is to immediately implement a strong quality control/quality assurance program with appropriate feedback mechanisms. This approach ensures that the data quality never becomes inadequate or questionable.

5.1 Quality Control Program

The quality control program will address as a minimum the following areas:

- Selection of the best methods, analyzers, and or samplers;
- Installation of equipment/instrumentation;
- Calibrations;
- Zero and span checks and adjustments of automated analyzers;
- Control checks and frequency;
- Control limits for zero, span, and other control checks, and respective corrective actions when limits are exceeded;
- Preventive and remedial maintenance;

- Recording and validating data; and
- Documentation of quality control information.

The quality control program will meet the monitoring objectives and quality assurance requirements of the regulatory agency and will minimize the loss of air quality and meteorological data due to malfunctions or out-of-control conditions.

The operator will be supplied with an "Operator Checklist" to aid the operator in his inspection of the monitoring stations. It will contain a sufficient number of key items to alert the operator of existing or potential problems. During the station visit, the operator will be required to document the previous zero/span calibration data at each station location. This data is used to compile drift control information.

If during a station visit a major malfunction is detected, the operator will document the downtime in the station logbook. The operator will then investigate the cause of the malfunction and notify the Project Director. For routine problems, the operator will initiate maintenance immediately. More serious problems may require consultation with the Project Director so that a plan of action can be initiated. The operator will have available in the field, equipment and the majority of spare parts necessary to maintain the monitoring station's equipment/instrumentation.

Each gas analyzer will be calibrated at each monitoring station on site at the time of installation and any time thereafter, if the accuracy falls outside of 15 percent. Quarterly calibrations will be conducted following installation even if the analyzer does not exceed the 15 percent control limit from Precision checks and Level 1 and 2 checks. All gases used in calibrations, or calibration checks (Precision, Level 1 and Level 2 checks) will be NBS traceable within 2 percent of analysis.

Level 2 checks (automated zero/spans) will be conducted once per day. Precision and Level 1 checks will be conducted bi-weekly. Level 1 and 2 checks will be at 80 - 90 percent of full scale. Precision checks will be at 16 - 20 percent of full scale. The calibration system's flow rates will be checked monthly against an NBS traceable volumetric standard. Meteorological sensors will be calibrated at the time of calibration and will be calibrated quarterly thereafter. Flows of the integrated and particulate samplers will be calibrated at least quarterly with NBS traceable volumetric flow standards.

5.2 Quality Assurance Program

Each Monitoring stations will be audited quarterly by an independent auditor. The auditor will conduct a systems and performance audit. The systems audit will evaluate siting, quality control procedures, documentation, etc. The performance audit will assess the accuracy of the air quality and meteorological instrumentation.

The analyzers will be audited using NBS traceable gases. All equipment will be independent of day-to-day operations equipment. The analyzer will be tested at zero and three upscale points approximately at 5 - 8 percent, 40 - 50 percent, 80 - 90 percent of full scale. The meteorological sensors will also be checked using NBS traceable standards and calibrated measurement mechanical devices.

A quality assurance program will be implimented for the analyses of the metals samples, particulate samples, and rain samples. This program will consist of duplicate analyses of samples, sample blanks collected and analyses performed, and spiked sample analyses performed.

6.0 Monitoring Equipment Specifications

This section provides specifications for the instrumentation and equipment that will be used to collect the air quality data from the monitoring stations. The instrumentation and equipment chosen to perform the air quality monitoring has been used successfully by Measurement for similar monitoring programs. The proposed instrumentation and equipment has been found to be reliable, accurate, and suited for the humid and salty environment of Hawaii.

The monitoring stations will be assembled into operating systems and tested in the field prior to being put on line to collect air quality data. Each piece of equipment and instrumentation shall undergo a rigorous test/check and refurbishment as required prior to being integrated into the operational monitoring stations. Testing will consist of performing a operational checks to verify that each piece of equipment was received from the supplier as ordered, refurbishment performed correctly, all accessories were received, and that each piece of equipment functions properly. Once the equipment has been verified to be operational and acceptable, the equipment will be integrated into the assigned monitoring station configuration. If a piece of equipment is found to be unacceptable, the vendor will be immediately notified and a plan for corrective action worked out. In the event corrective action cannot be worked out within an acceptable manner or acceptable time schedule an equivalent piece of equipment will be temporarily substituted. When system integration is complete, an additional operations test will be performed to verify system operation.

Each of the monitoring stations are equipped to operate in a stand-alone manner or as an integral part of a monitoring network. The following equipment and instrumentation will be supplied for the monitoring program:

- Hydrogen Sulfide (H2S) - Meloy Laboratories SA-285E or SA-185-2A

- Sulfur Dioxide (SO2) - Meloy Laboratories SA-285E or SA-185-2A

- Hydrogen Sulfide Drilling/Development Area - VICI Metronics Colortec H2S Passive Dosimeters

- Atmospheric Metals - Measurement Technologies 880 S

- Particulates Inhaleable (PM 10) - Sierra Andersen SAUV-11H with G313 Flow Controller

- Total Suspended Particulates (TSP) - General Metal Works GMW 2000H

- Wind Direction - Met One 024 Wind Direction Sensor

- Wind Speed - Met One 014 Wind Speed Sensor

- Ambient Temperature - Met One 060 Temperature System

- Vertical Winds - Gill 27106 Propeller Anemometer

- Precipitation - Weathermeasure/Weathertronics 6020 Tipping Bucket Rain Gage

- Rainwater - Weathermeasure/Weathertronics 6330 Rain Gage

- Data Acquisition - Odessa Engineering DSM 3260 Met/Air Option

- Calibration Continuous Gas Analyzers - Radian RAD-IIIB Calibration System

- Radon - Terradex Corporation Track Etch Type F Radon Detector

6.1 Shelter Description

The equipment and instrumentation for the primary monitoring station (Site 1) will be housed in 8′ X 18′ X 8′(H) portable office building. Temperature within the shelters will be environmentally controlled by an efficient air conditioner to protect the instrumentation and provide a pleasant working environment for the operations personnel.

The 10 meter crank-up meteorological tower mounts to the front of the shelter for easy access. Sulfur dioxide and hydrogen sulfide is extremely reactive and easily absorbed. Therefore, a heated stainless steel intake sample manifold with blower, teflon and stainless steel sample handling valve train and sample lines is provided with each shelter. A PVC exhaust manifold vented to the bottom of the shelter is provided to prevent exhaust gas from building up inside the shelters. The shelter is equipped as follows:

- o Five position gas bottle rack for securing expendable gas cylinders
- o 10 meter meteorological tower
- o 60 amp load center, 230 VAC single phase
- o Dual work benches for instrumentation placement
- o Storage shelving for parts and expendables
- o Step stool
- o Chair
- o Outside light
- o Heavy duty tamper proof door
- o High quality vinyl flooring with wood paneling on the walls
- o Insulated walls, ceiling, and floor minimum R-16 rating

- Heated sample manifold/handling system with blower

- PVC exhaust manifold

- Particulate sampler mounting platform

An additional 8′ X 8′ X 8′ shelter is provided for housing the two continuous duty 10 KW Generac propane generators. This shelter protects the generators from the weather and vandalism and helps abate the noise produced from the generators. This shelter will be located a minimum of 100 feet from the air quality shelter.

6.2 Sulfur Dioxide and Hydrogen Sulfide Analyzers

Both the Meloy Models SA 185-2A and SA 285E sulfur analyzers are EPA designated equivalent methods for the measurement of ambient concentrations of sulfur dioxide (SO2) when used with the supplied H2S scrubber. Each Meloy is equipped with options for linear output, reignite timer circuit, press to read rotameter, manual zero and span, and rack mounting. These options are all EPA-approved. The analyzers can be used to measure SO2 and hydrogen sulfide (H2S). To measure SO2, the ambient sample line is equipped with a H2S scrubber so that only SO2 is measured. To measure H2S, the ambient sample line is equipped with a SO2 scrubber and only H2S is measured.

These Meloy sulfur analyzers use a flame photometric detector to continuously monitor sulfur compounds. The flame photometric detection technique involves monitoring the intensity of light emitted at a wave length of 394 nm by burning sulfur compounds in a hydrogen-air flame. The excellent sensitivity of the analyzer is achieved by thermally isolating the photomultiplier tube from the burner assembly and thermoelectrically cooling the photomultiplier tube. Specifications for the Meloy SA 185-2A and 285E are as follows:

Range:	0 to 0.5 ppm
Noise:	0.002 ppm
Minimum Detectable Concentration:	0.002 ppm
Zero Drift:	0.002 ppm (24 hours)
Span Drift:	±3% per day
Linearity:	±1% of full scale
Precision:	0.001 ppm
Operating Temperature Range:	20 deg to 30 deg C
Interference Equivalent:	±0.01 ppm

6.3 Hydrogen Sulfide Passive Dosimeters

Hydrogen sulfide will be measured in the drill/development area by VICI Metronics Colortec dosimeters. The dosimeters consist of a subdivided disc treated with a solution that reacts colorimetrically with hydrogen sulfide gas. As hydrogen sulfide is detected, it changes the color of the different treated areas of the disk depending on concentration and time of exposure. The dosimeters are placed on fence post around the perimeter of the drill/development area. The dosimeters are read weekly and changed each monitoring month or as hydrogen sulfide is detected. The detection limit is about 5 ppb over a seven day monitoring period.

6.4 Particulate Measurement

Three types of samplers are used for the collection of particulate samples. A Measurement Technologies Model 880S integrated sampler is used to collect metals samples for analyses on contaminate free 47 millimeter Teflon filters. Total suspended particulate are collected on high purity 8 X 10 inch glass fibre filters by a hi-volume sampler, and respirable particulates that are less than 10 microns in size are collected by a PM-10 size fractionated sampler on high purity 8 X 10 inch glass fibre filters.

6.4.1 Metals Measurement

A Measurement Technologies Model 880S integrated sampler is used for collection of metals in the atmosphere. The integrated sampler collects metals samples on 47 millimeter teflon filters. A telflon filter head assembly is attached to a pole suspended above the integrated sampler 1.5 meters above the ground. The integrated sampler draws a regulated 1 liter per minute sampler through the filter head for a twenty-four hour sample period. A precision timer turns on the sampler at 00:00 hours the day the sample is to be collected. A precision elapsed time indicator shows sample run time. Once the samples are collected, they are placed in numbered plastic petri dishes and sent to an analytical laboratory for analysis by x-ray fluorescence Protocal 5. Specifications are as follows:

Sample Pump:	High capacity 12 volt DC pump with inert plastic head and viton diaphragm material
Flow capacity:	0-3 LPM
Flow Control:	Sapphire orifice with precision metering valve
Materials in contact with sample:	Teflon, Kynar, Glass, 316 SS, Viton, and chemically inert plastic
Elapse Time Meter:	0-99999.99 hours
Power Requirement:	12 volts DC, 200 ma or 120 volts AC 60HZ

6.4.2 Particulate (PM 10)

The Andersen Model SAUV 11-H PM-10 particulate sampler, samples suspended particles in the air at 40 ACFM through a circumferential inlet designated as the Size Selective Inlet. The symmetrical design of the inlet insures wind-direction insensitivity and the collection efficiency is independent of wind speed from 0 to 36 kilometers per hour.

Once the particles enter through the inlet they are accelerated through multiple circular impactor nozzles. Particles larger than 10 microns have a greater momentum than particles less than 10 microns, therefore, the larger particles impact onto a greased impaction surface where they are trapped. The particles smaller than 10 microns are carried vertically upward by the air flow and down multiple vent tubes to the 8-inch by 10-inch hi-vol filter, where they are collected. The larger particles that settled on the greased collection shim are removed/cleaned during prescribed maintenance periods.

The quartz fiber hi-vol filter is weighed before and after sampling. The weight increase is the mass of the particles smaller than 10 microns. The mass concentration of PM-10 particles (micrograms per cubic meter) is determined by dividing the particulate mass (micrograms) by the sampled air volume (cubic meters). The air volume is properly maintained at a constant rate of 40 ACFM with the Andersen Model G313 electronic mass flow controller. Specifications for the SAUV-11H are as follows:

Model:	SAUV 11H
Inlet Collection Efficiency:	SSI has a cut point of 9.7 microns over a wind speed of 0-36 KPH; Meets EPA's PM-10 Federal Reference Method (RFPS-1287-063).

Flow Rate:	40 cubic feet per minute
Filter Media:	8-in. x 10-in. quartz fiber filter media.
Vacuum Supply:	Axial blower with Model GB1 carbon brushes
Accuracy of Mass Flow Control:	40 CFM with < 1% deviation over 24 hrs.
Power Required:	100/115 VAC, 50/60 Hz.,8A max., 230 VAC, 50 Hz., 4 A max
Dimensions:	64 in H max, 28 in Dia max
Weight:	95 lbs.

6.4.3 Total Suspended Particulates

The GMW 2000H hi-volume sampler is used to collect total suspended particulate samples. The sampler is equipped with a recorder for measuring flowrate as a function of time for a 24-hour sampling period. The flow recorder is permanently mounted inside the hi-volume sampler shelter to insure proper operation of the inking system, transducer, and synchronous motor during periods of severe weather.

The sampler is sequenced by a programmable 24 hour synchronous timer for automatic operation. The samplers are operated from midnight to midnight on a designated every sixth day sample schedule. The sampler is designed to meet or exceed all Federal performance and dimensional specifications including those in 40 CFR Part 50, Appendix B, dated July 1, 1975. Gelman type A-E glass fiber filters or equivalent are used as a collection medium for particulate sampling. Each filter lot possesses a collection efficiency of 99 percent for particles of 0.3 um in diameter. Specifications for the GMWL-2000H are as follows:

Model:	GMWL-2000H
Motor HP:	0.6
Speed:	13,500 RPM
Amperage:	4.9
Wattage:	440
Maximum Flow Rate:	52 CFM
Minimum Flow:	20 CFM
Power Source:	120 VAC/60 HZ

6.5 Calibration Equipment

Calibration equipment will be provided for the calibration of the sulfur analyzers, particulate samplers, data acquisition system, meteorological equipment, and gas calibration system.

6.5.1 Gas Calibration System

The Radian Corporation RAD-IIIB Dynamic Calibration System is used for the calibration of the sulfur analyzers. The RAD-IIIB is both a multipoint calibration device under manual control and a computer controlled span and zero calibration source. The analyzers are automatically zero spanned each day using the data aquisition system. Specifications are as follows:

Model Number:	RAD-IIIB
Span Gas Output Range:	0.050-2.0 ppm with 80 ppm gas standard concentration
Source Gas Flows:	0-20 cc/min and 20-120 cc/min
Dilution Air Flow:	2000-9000 cc/min dilution 100-1500 cc/min zero air output
Input Pressure Gases:	20-30 psig

Flow Control Accuracy:	2%
Temperature Range:	10 deg C to 40 Deg C
Drift	Less than 0.02% in 24 hours

6.5.2 Meteorological, Flow and Electronics Calibration

Calibration of the meteorological equipment and data acquisition system will be performed by the use of mechanical standards and electronic standards. Flow verification will be performed through the use of precision NBS traceable bubble meters and calibrated flow orifices with precision water monometers. Gas standards will be NBS traceable 2% of analysis. The following calibration devices will be used for calibration of the instrumentation and equipment.

- o Wind Direction Sensor Linearity - Degree Wheel
- o Wind Speed Sensor Accuracy - Synchronous Motors
- o Temperature - Precision Resistors and Thermometers
- o Data Acquisition System - Voltage, Frequency, Resistor Standards and Calibrated Multimeters
- o Calibrator Flow - NBS Traceable Bubble Meter and flow orifices with water monometer
- o Gases - NBS Traceable 2% of Analysis

6.6 Data Acquisition System

The Odessa Engineering DSM 3260 data acquisition system (DAS) equipped with the air quality/meteorology option will be used for gathering data from the air quality and meteorological instrumentation. The configuration used in the air monitoring stations will consist of the DAS, hardcopy printer, operator console, and modem.

The primary mechanism to be used for data retrieval will be through the use of telephone lines and dial-in modem. On a every other day basis each station will be called to retrieve data from the DAS. Air quality engineers will have instant access to data for review to ensure that instrumentation is working properly. Impending problems can be identified early and corrected. The hardcopy from the printer and data cartridges will be used for backup in the event of problems with data communications. Specifications are as follows:

Model Number:	DSM 3260 AQM/MET
Number of Analog Inputs:	16
Analog Input Ranges:	±.1, ±1, ±5, ±10 volts
A/D Resolution:	12 bits
Digital Status Inputs:	16
Digital Control Outputs:	16 relay contacts
Memory:	64K Program ROM, 16K Data
Data Reporting:	Software and switch selectable recording periods
Battery Backup:	120 hour for clock and memory
Data Storage:	Solid state cartridges
Communications:	Serial RS-232 and Centronics Parallel Ports
Power:	115 volts AC or 12 volts DC
Environmental:	Temperature 0-140 degrees F, Humidity 0-95% non condensing

6.7 Meteorological Instrumentation

The meteorological instrumentation was chosen for its proven reliability, ease of maintenance, sensitivity, accuracy, and ability to operate under extreme environmental conditions. The meteorological instrumentation and the Odessa data acquisition system comprise the meteorological monitoring system. Each meteorological sensor interfaces directly with the DAS after passing through a lightning protection isolation box. General Semiconductor tranzorbs are connected from each of the individual meteorological instrumentation sensor signal leads to earth ground. Tranzorbs are extremely fast high current clamping diodes. Crank-up telescoping meteorological ten meter towers will be supplied to mount the meteorological instrumentation. Standard wind deviation and sigma W will be calculated by the DAS by sampling the signals provided from the sensors each second.

6.7.1 Wind Direction

Wind direction will be measured with the Met One Model 024 lightweight air foil sensor. The wind direction sensor is designed for fast response with a minimum of overshoot. The wind vane is connected to a long thin shaft linked mechanically to a low-torque precision potentiometer. A constant voltage is applied across the potentiometer with the voltage between the wiper and ground being proportional to difference in wind vane alignment with respect to north or 360 degrees. The DAS provides the constant voltage reference and computes the wind direction from the input voltage. Wind direction sensor specifications are as follows:

Model Number:	024
Accuracy:	3 degrees
Wind Direction Operating Range:	0 to 360 degrees
Operating Temperature Range:	-58 to 150 degrees F

Response Distance Constant:	Less than 3 feet
Starting Threshold:	0.6 mph
Linearity:	1% of full scale
Damping Ratio:	0.4-0.6

6.7.2 Wind Speed

Wind speed will be measured with the Met One Model 014 three-cup anemometer. The anemometer is a low threshold sensor designed to collect accurate wind speed data in climates where wind and temperature ranges are extreme. The cup assembly is attached to a long vertical shaft which is linked to a rotating magnet which causes a precision reed switch to open-and-close depending on which pole of the magnet passes by the switch. The rotation of the magnet produces a pulse square wave signal that is measured by the DAS. The frequency of the square wave is proportional to the wind speed in mph. Wind speed sensor specifications are as follows:

Model Number:	014
Maximum Operating Range:	0-125 mph
Calibrated Range:	0-100 mph
Starting Speed:	0.6 mph
Temperature Range:	-58 to 150 degrees F
Accuracy:	0.25 mph

6.7.3 Ambient Temperature

Ambient air temperature will be measured with the Met One Model 060-2A temperature sensor mounted in a Met One naturally aspirated temperature shield. The 060-2A temperature probe consists of a dual element thermistor with each element chosen for linearity of response. Temperature measurement system specifications are as follows:

Calibrated Temperature Range:	-58 to 122 degrees F
Response:	10 seconds in still air
Linearity:	±.1 degrees F
Accuracy:	0.1 percent

6.7.4 Vertical Wind Speed

The Gill Model 27106 Propeller Anemometer manufactured by R.M. Young Company will be used to measure vertical wind speed. Vertical wind speed and standard deviation (sigma w) will be measured and calculated with the DAS. The anemometer uses a microminiature DC generator attached to the propeller shaft to generate a DC voltage proportional to the vertical wind speed. The propeller anemometer measures upward and downward wind flow when the anemometer is mounted in a vertical position. The anemometer specifications are as follows:

Model Number:	27106
Maximum Operating Range:	70 mph each direction of rotation
Starting Speed:	0.3 to 0.5 mph
Calibration Range:	-25.2 mph
Accuracy:	3 percent
Response Distance Constant:	3.1 feet

6.7.5 Precipitation Measurement

Precipitation is measured by a tipping bucket rain gage and plastic vessel type rain gages. The tipping bucket rain gage is used to collect historical rain data on a real time basis. The plastic rain gages are used to collect rainwater data for laboratory analyses.

6.7.5.1 Automated Precipitation

A Weathermeasure/Weathertronics Model 6020 tipping bucket precipitation gage is used to continuously collect precipitation an a real time basis. The precipitation gage bucket produces a switch closure each time the bucket tips that is counted by the data aquisition system. The bucket tips one time for each 1 hundredth inch of rain.

Model Number:	6020
Operating Range:	0 to 8 inches
Resolution:	0.01 inches
Dimensions:	8 inch diameter orifice, 18 inch height
Accuracy:	0.5% calibration at 0.5 inches per hour

6.7.5.2 Rain Water Collection

The Weathermeasure/Weathertronics Model 6330 plastic rain gages are used to collect rainwater samples for analyses of anions and dissolved metals. The rain gages have a 4 inch orifice with a gage height of 14 inches. An internal 1 inch measuring tube indicates precipitation on a graduated tube to 0.01 inches for minor divisions and 1.0 inches for major divisions. Rain samples are collected for a 15 day period prior to being sent to a laboratory for analyses. The rain gages are cleaned with pure deionized water prior to being set for new rain samples being collected.

6.7.6 Telescoping Crank-Up Meteorological Tower

The wind direction, wind speed, vertical anemometer, and temperature sensors will be mounted on Tri-Ex MW-33 10 meter crank-up towers. The MW-33 tower manufactured by Tri-Ex is a free standing four section telescoping tower provided with a hand crank to raise and lower instruments mounted on the top section. This arrangement ensures ease of instrumentation maintenance while eliminating the hazards associated with an operator climbing the tower. Specifications are as follows:

Extended Height:	33 feet (10.1 meters)
Retracted Height:	11.5 feet
Wind Load Limit:	8.5 sq. ft. at 50 mph
Number of Sections:	4
Construction Materials:	Galvanized steel

6.8 Radon

Radon will be measured by Track ETCH type F radon detector badges. The badges are manufactured by Terradex Corporation. Radon causes a special film to be exposed when radon is detected. The amount of film exposure is proportional to radon concentration. The badges will be placed in the development/drill site area for one month then sent to a laboratory for reading.

7.0 Data Reduction, Validation and Reporting

These sections outline the types of data reduction, data validation and data reporting procedures to be implemented for processing the data collected during the monitoring program.

7.1 Data Reduction

At each monitoring station, the analog voltages from each analyzer/instrument will be continuously digitized by the A/D converter of the data acquisition system (data system). The data system will sample wind data once a second and sample other parameters once every 10 seconds. A five-minute average will then be calculated from these values and stored in memory. On the hour, after 12 sets of five-minute averages have been collected, an hourly average will calculated. The data system will activate the printer and transfer this data to the solid state cartridge and printer for hard copy printout.

At midnight, a daily summary will automatically be generated. This summary includes all of the one hour averages for the day, the daily 24 hour averages, and the daily rolling averages. In addition, the automatic Level 2 zero/span data collected will be listed.

Approximately every 15 days, the operator will collect the following data from each monitoring station and ship to Measurement's office:

- o Hardcopy printout containing the previous 15 days of aerometric data;
- o Copies of station logs;
- o Operator checklists;

- Malfunction report forms; and
- Calibration and internal quality control forms.

The data received by Measurement will be logged into the data status log, and forwarded for data processing. The Data Processing manager will compare the polled data acquisition system data stored on hard disc to the diskette data received from the field. At this point, a computer program will be used to determine if any data is missing from the field data. If missing data is available on the hardcopy it will then be merged into the disk files. The hard disc data will be stored for data retrieval until the data record has been completely reviewed by the Quality Assurance manager.

7.2 Air Quality Data Validation

All data will be edited and then validated by a data editor. A printout of all one-hour averages for the month will be reviewed, and if suspicious or unusual concentrations/readings are noted, the editor will then review the data for that period. The criteria that will be used to invalidate data include the following:

- If daily span values for gas analyzers are not within 25 percent of the current Level 2 span concentration. Span values outside the 25 percent error limit are acceptable if Level 1 checks using another calibrator indicate that the auto calibration system, not the analyzer malfunctioned.
- If SO2 values detected and no H2S values, the data is highly suspect if they occur consistently over several hours or days.
- Consistently high or low span values are suspect if there are high or negative zero calibration values.

- Extremely high or low response values for extended periods which are inconsistent with known ambient levels for a particular monitoring station.
- Known operational problems have been identified by routine maintenance and documented in instrument logs, instrument checklists, and downtime reports.

One of the most valuable editing aids will be the Level 2 auto calibration data. This data will be summarized monthly for each monitoring station. The time the calibration occurred each day, the calibration gas concentration, and the zero and span response each day will be included in the summary to track instrument zero and span drift for indications of instrument malfunctions. Additional information for data validation will be obtained from the station logbooks and operator checklists. Finally, professional judgement will be used according to the following types of guidelines:

- Did an identifiable problem exist at the time the data was collected?
- If so, would its influence on the data be comparable to the normal uncertainty in the measurements (as identified by audits)?

If no problem can be identified, the data will be accepted. If a problem exists, but its influence on the data is small, the data may be accepted. Otherwise the data will be deleted.

Once the data has been reviewed and edited, permanent data base of hourly averages will be compiled. All subsequent data processing will be done using this data base.

7.3 Meteorological Data Validation

The hourly averaged meteorological data for each monitoring station will be examined for unusual variations or fluctuations that indicate instrument or software malfunctions. Comparisons of data between the various monitoring stations and between different measurement methods will be made to identify inconsistencies indicating bad data. The types of procedures applied in editing the meteorological data are described below.

7.3.1 Wind Data

Some of the inconsistencies which may indicate bad wind data include the following:

- Persistent calms or persistent wind direction, especially during daylight periods.
- Highly variable wind directions (more than 90 degrees between hourly averages) with strong wind speeds.
- Persistent counterclockwise turning of the wind direction with height above the ground.
- Persistently higher wind speeds near the ground than at higher levels above the ground.
- An absence of calms or low wind speeds over a long period.
- Wind speed or wind direction persistently greater or less than similar measurements at another nearby location(s).

7.3.2 Temperature Data

Some of the types of inconsistencies which may indicate bad temperature data include the following:

- Rapid fluctuations over a short time period (2 degrees F to 3 degrees F or more in five minutes, or 5 degrees F to 10 degrees F or more between hourly averages).
- Consistently high or low readings compared to nearby locations.
- Super adiabatic vertical temperature profile at night, with cloudy skies, or low sun angle.
- Decreasing temperature with height in the evenings when wind speeds are low.

After data validation is completed, a file will be created containing the permanent data base for the network. All subsequent reports will be generated from these files. The edited data base and the hardcopy data will be archived at Measurement.

7.4 Data Reporting

Measurement will compile monthly, quarterly and annual data reports at the end of each monitoring period.

7.4.1 Monthly Reports

A monthly monitoring report will be compiled at the end of each monitoring month. The report will include data collected from each of the monitoring stations. The monthly reports will include the following types of information:

- An operations narrative of significant events and activities.
- A table showing the hourly summary data for each parameter monitored for the month.
- A table showing the two maximum hour averages for each pollutant for the month.

- Tabular pollution and wind roses for the month.
- Graphical pollution and wind roses for the month.
- A listing of the automated zero/span data.
- The data and calculations to determine stability classifications.

7.4.2 Quarterly Reports

The quarterly monitoring reports will include the data provided in the monthly report, a description of the monitoring program, site maps, quality assurance data, and quarterly summary data and tables. The types of quarterly information included in the quarterly reports are as follows:

- A description of the monitoring program and monitoring stations.
- A map showing monitoring station locations in relation to the plant.
- A tabular data capture summary for each monitored parameter for the quarter.
- A quality assurance summary with quarterly audit results.

7.4.3 Annual Report

The annual monitoring report will include the information provided in the quarterly report on an annual basis. Conclusions and recommendations of the data collected during the monitoring program will also be included.

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